

A New Framework for NASA Earth “Strategy to Action”

**Miguel O. Román, PhD
Leidos Civil Group**

MODIS/VIIRS Science Team Meeting - 5/14/2023

Hot Buttons....

NASA's drifting climate satellites could find new life as wildfire and storm watchers

Agency mulls end for Terra, Aqua, and Aura satellites, but researchers lobby for an extension

21 NOV 2022 • 1:00 PM • BY [PAUL VOOSEN](#)

Science



The poster features the NASA logo in the top left corner. The main title is "Request for Information" in large white font. Below it, the text reads "To inform NASA's Terra, Aqua, and Aura Drifting Orbits Workshop". The background is a composite image showing the Earth from space and three satellites (Terra, Aqua, and Aura) in orbit. A QR code is located in the bottom right corner of the poster. At the bottom, it says "Due: **October 11** /// More information: nspires.nasaprs.com".

“At a fundamental level, you’re trading a Swiss Army knife with 36 features down to 22.”

2023 Senior Review: Orbital Drift Science?

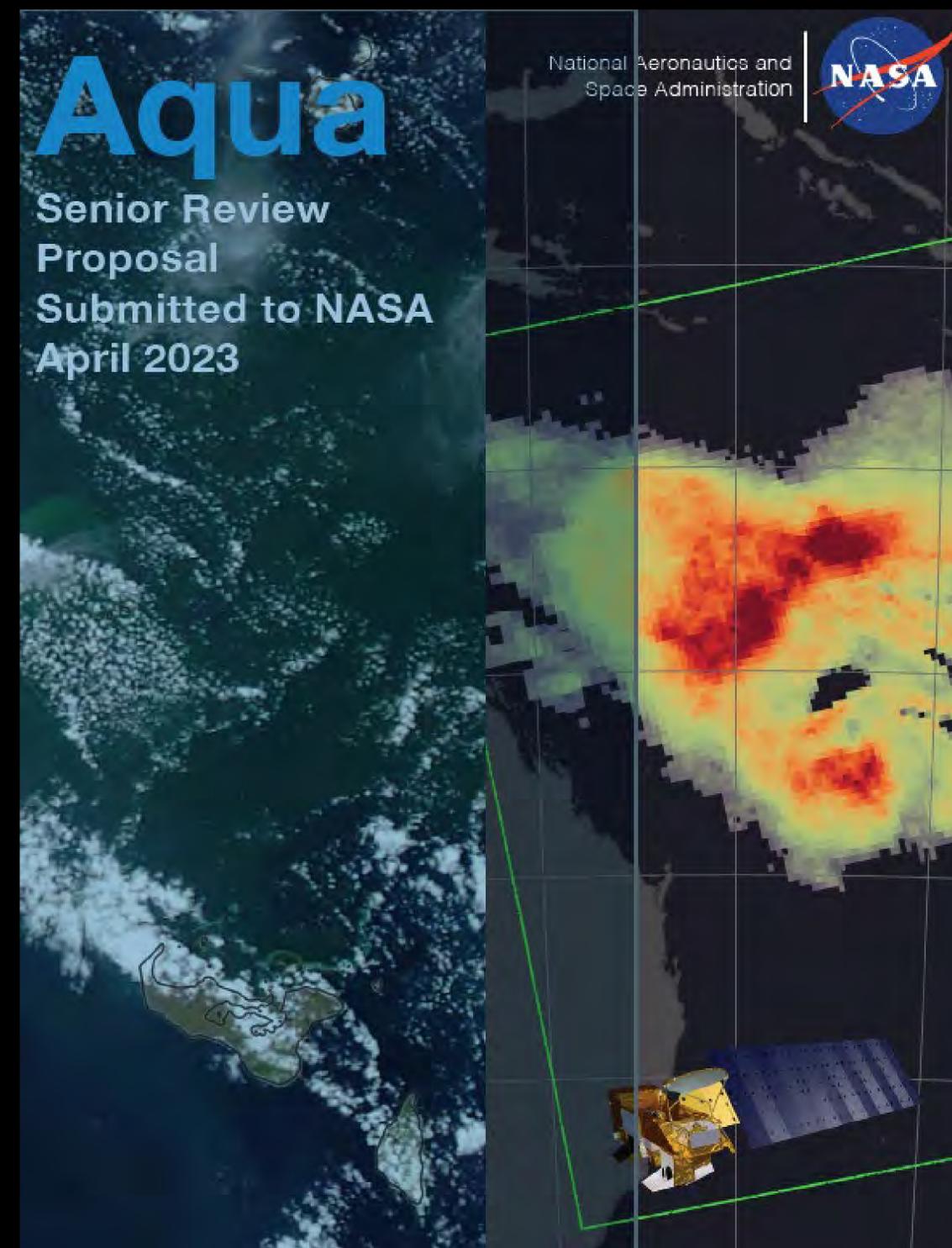


TERRA
The Flagship Earth Observing Satellite

2023

National Aeronautics and Space Administration | 

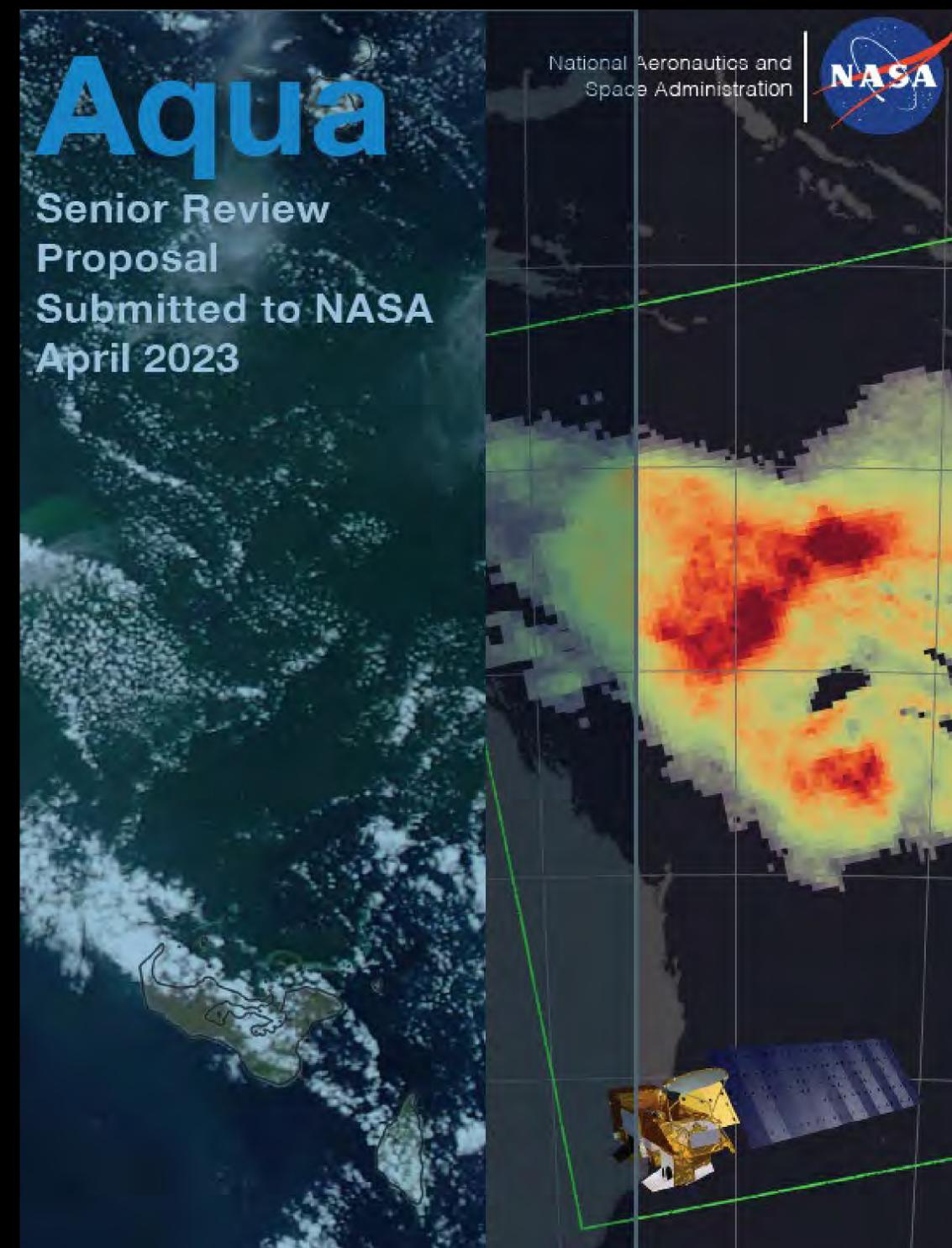
Proposal
Senior Review 2023
of the Mission Operations and Data Analysis
Program for the Earth Science Operating Missions



Aqua

Senior Review
Proposal
Submitted to NASA
April 2023

National Aeronautics and Space Administration | 



White Paper on
Continuity of NASA Satellite Climate and Earth Science Data
Records into the NPP/JPSS-1 Era

Coordinated System/Infrastructure Elements Required for
Production and Sustainability of Climate Quality Data Records

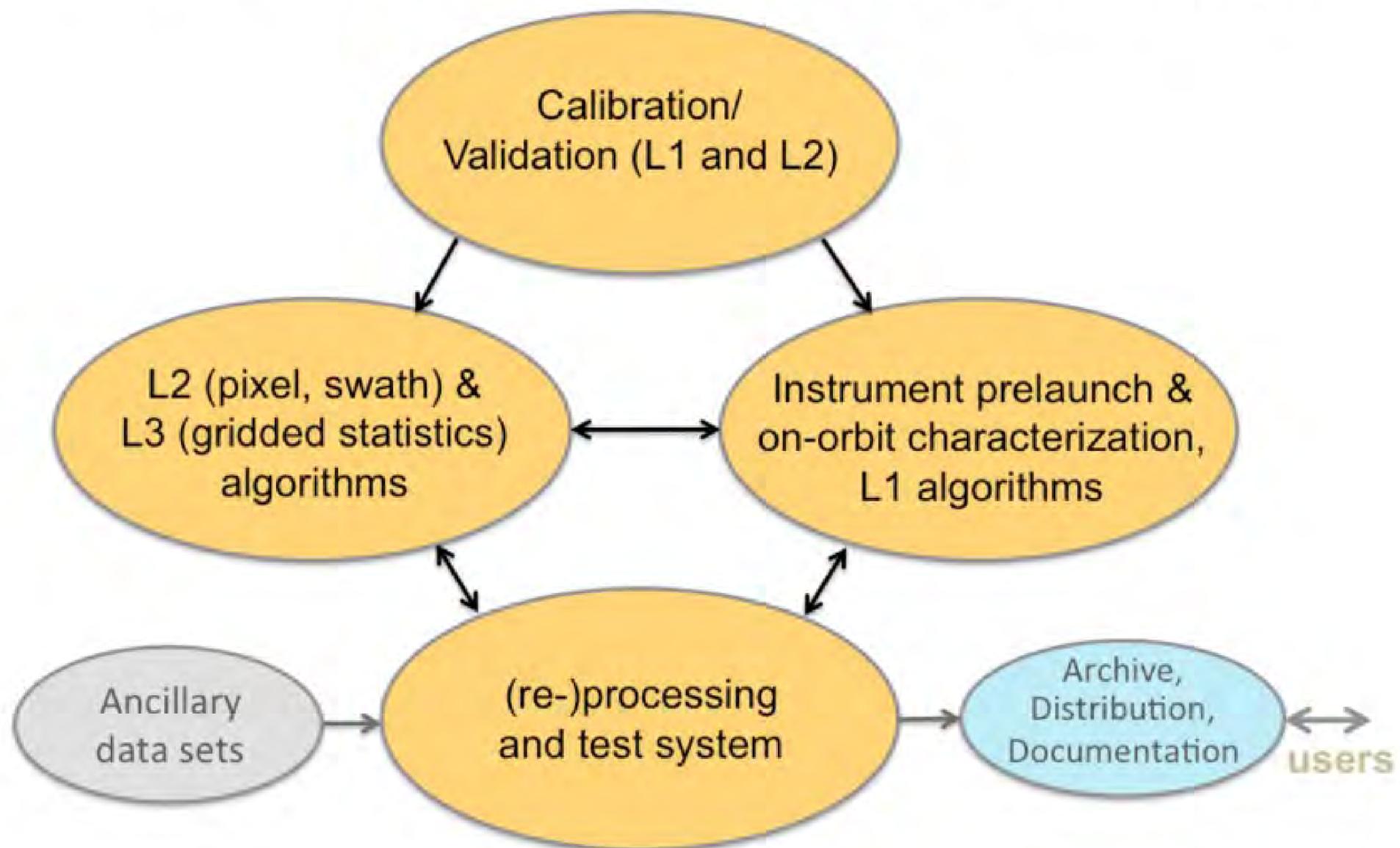


Fig. 2. Integrated elements required for production and sustainability of CESDRs.

S-NPP/N20/N21

- NOAA EDR Evaluations [Done]
- NASA VIIRS C2 Products [In Progress]
- 2024 ROSES A.33 Solicitation?
- NOAA-CDRs?
- VCST-STAR L1 Cal Coordination

Platnick et al., 2012



NASA's
Terra, Aqua, and Aura

DATA CONTINUITY WORKSHOP

May 23 - 25, 2023 / 11 AM - 6 PM EDT

Direct Link to RFI



More Information



Thriving on Our Changing Planet

A Decadal Strategy for Earth Observation from Space



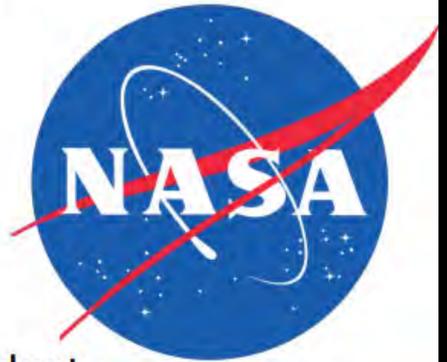
#EarthDecadal

The National
Academies of

SCIENCES
ENGINEERING
MEDICINE

NASA Portfolio Balance

- Earth Science research: *maintain* at approximately 24% of the budget (22-26%)
 - Includes 18% for openly competed research and analysis
 - Includes approximately 3% each for computing and administration
- Flight programs (including Venture): *maintain* 60% of the budget
- Mission Operations: *maintain* at 8-12% of the budget
- Technology program: *increase* from current 3% to about 5%
- Applications program: *maintain* at 2-3% of the budget



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SCIENCES • ENGINEERING • MEDICINE

EARTH SYSTEM OBSERVATORY

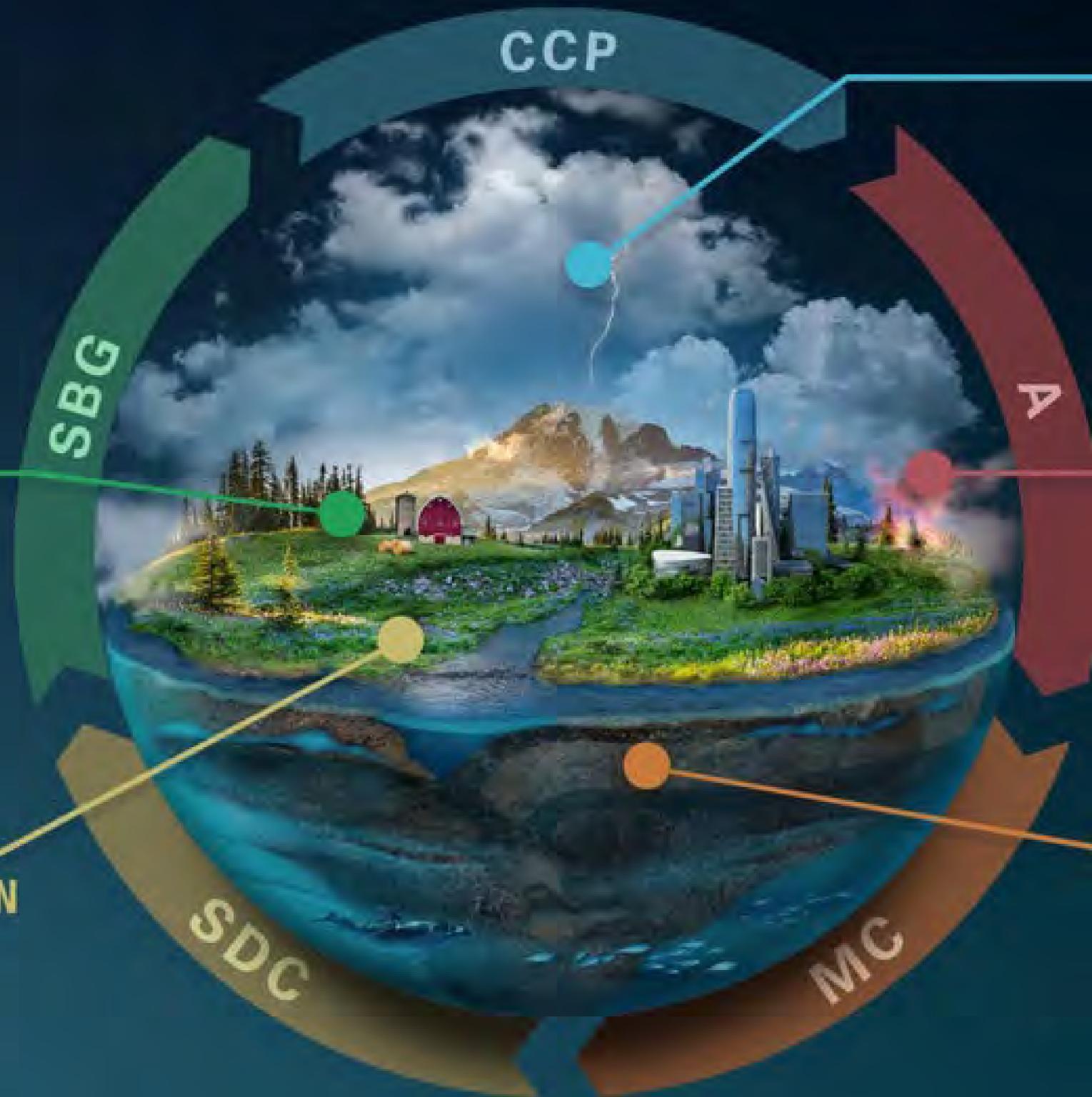
INTERCONNECTED CORE MISSIONS

SURFACE BIOLOGY AND GEOLOGY

Earth Surface and Ecosystems

SURFACE DEFORMATION AND CHANGE

Earth Surface Dynamics



CCP

CLOUDS, CONVECTION AND PRECIPITATION

Water and Energy in the Atmosphere

A

AEROSOLS

Particles in the Atmosphere

MC

MASS CHANGE

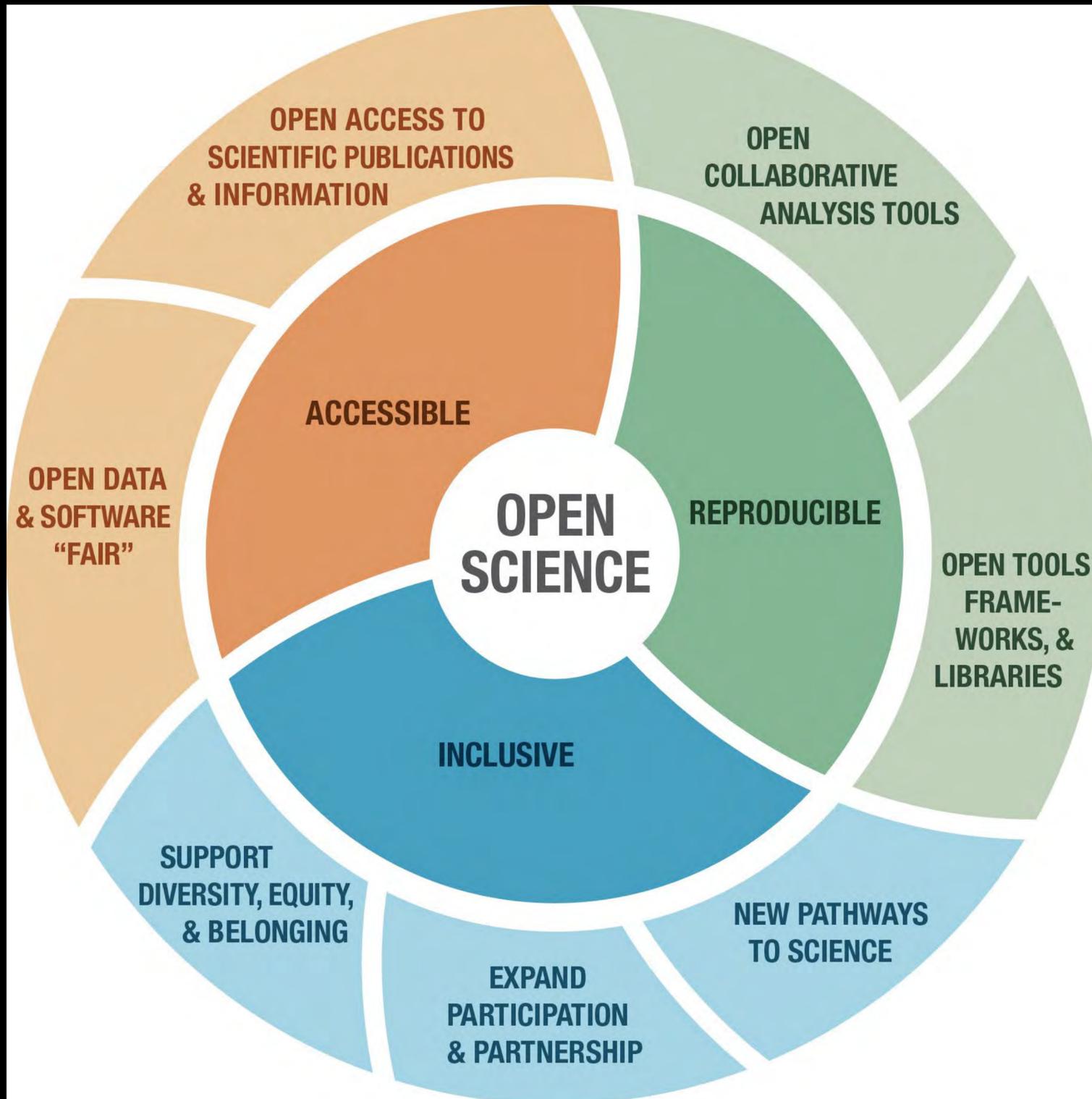
Large-scale Mass Redistribution

SBG

SDC

Table 1.4.1: Top-level science goals, prioritized objectives, and contributing Terra instruments cited in the ESAS2017 report

Top-level goal	Priorities	Terra contributors
H-1. Coupling the water and energy cycle	M	CERES
W-2. Predictions of weather and air quality	M	MODIS
W-5. Air pollution processes and distribution	M	MISR, MODIS
W-6. Air pollution processes and trends	I	MISR, MODIS
W-9. Role of cloud microphysical processes	I	MISR, MODIS
E-2. Fluxes between ecosystems, atmosphere, oceans, and solid earth	M	MISR, MODIS
C-2. Climate feedback and sensitivity	M, V, I	CERES, MISR, MODIS
C-3. Carbon cycle, including CO ₂ and CH ₄	V, I	MODIS, MOPITT
C-4. Atmosphere-ocean flux quantifications	V	CERES
C-5. Aerosols and aerosol cloud interactions	V	MISR, MODIS
C-8. Causes and effects of polar amplification	V, I	CERES, MISR, MODIS
S-1. Large-scale geological hazards	M, V	ASTER, MISR, MODIS
S-2. Geological disasters	M, V	ASTER, MODIS
S-4. Landscape change	I	ASTER, MODIS
S-7. Management of energy, mineral, and soil resources	I	ASTER, MODIS



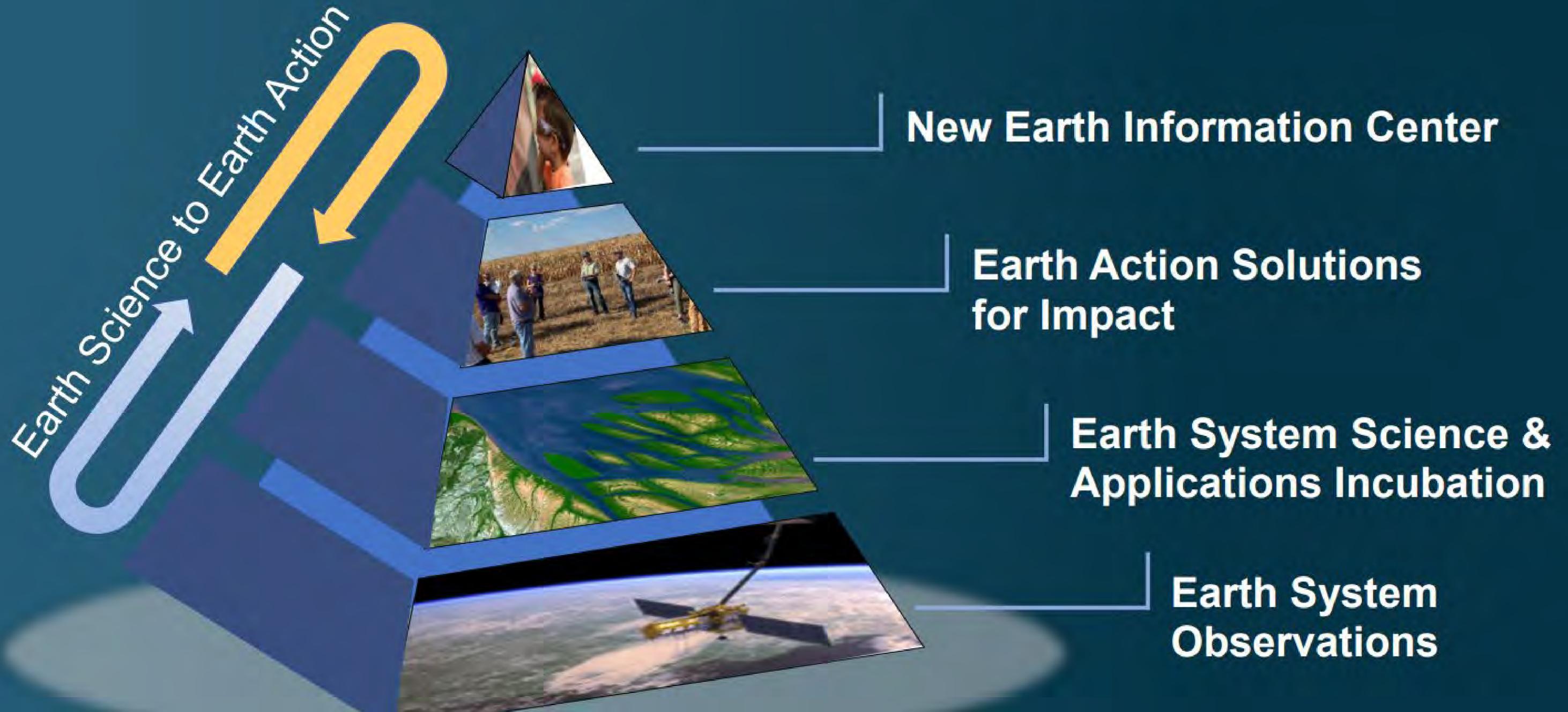
Ramachandran, et al., 2021

Let's Talk Open Science



Data Continuity is a
Precondition to
achieving Open Science.

NASA Earth Action Strategy





Credit: Rob Simmon

- MODIS/VIIRS are essential tools for human understanding, accountability, and transparency.
- Immeasurable economic, scientific, “pop-culture” impact (+ Citations than HST).
- Growing # of Followers: 4 Million Unique IDs across multiple disciplines.
- Strong industry advocacy and federal stakeholder buy-in.

Science During Crisis: Best Practices, Research Needs, and Policy Priorities



Rita R. Colwell and Gary E. Machlis

AMERICAN ACADEMY OF ARTS & SCIENCES

SUSTAINABLE URBAN SYSTEMS: ARTICULATING A LONG-TERM CONVERGENCE RESEARCH AGENDA



JANUARY 2018



A REPORT BY THE ADVISORY COMMITTEE FOR
ENVIRONMENTAL RESEARCH & EDUCATION

PREPARED BY THE SUSTAINABLE URBAN SYSTEMS
SUBCOMMITTEE

SPONSORED BY THE NATIONAL SCIENCE FOUNDATION

APPLIED ECOLOGY

A framework for research on recurrent acute disasters

Gary E. Machlis^{1*}, Miguel O. Román², Steward T. A. Pickett³

Disaster science examines the causes, behaviors, and consequences of hazardous events, from hurricanes to wildfires, flooding, and major industrial accidents. Individual disasters are recurring more frequently and with greater intensity. Recurrent acute disasters (RADs) are sequential disasters that affect a specific locale over time. While disaster science has matured in recent years, understanding of the distinctive characteristics of RADs varies by discipline and lacks predictive power. A theoretical framework is presented by borrowing in part from mathematical topology and disturbance ecology. The recurrent disasters affecting Puerto Rico 2017–2020 are examined as a case example to test the framework. A key variable is the complex characteristics of legacy conditions created by one disaster that influence the effects of subsequent disasters. Substantial improvements in disaster response, recovery, and preparedness can be gained by adopting a RAD-based approach.

National Academies of Sciences, Engineering, and Medicine.
"Resilience for Compounding and Cascading Events." (2022).

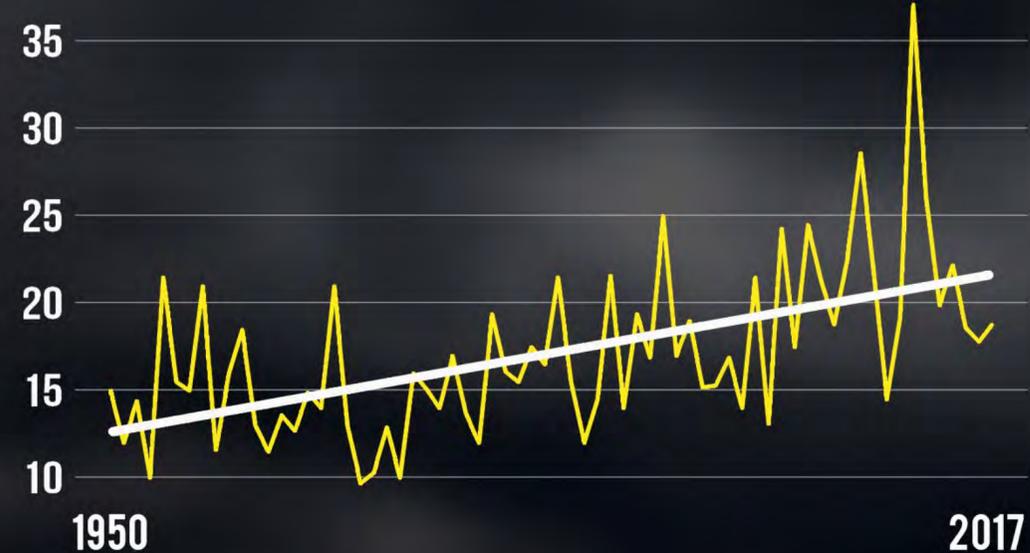
<https://nap.nationalacademies.org/catalog/26659/resilience-for-compounding-and-cascading-events>

Relevant Increasing Trends

- intensity
- variability
- frequency
- vulnerability
- economic and social costs

BIGGER TORNADO OUTBREAKS

Number in the largest outbreaks



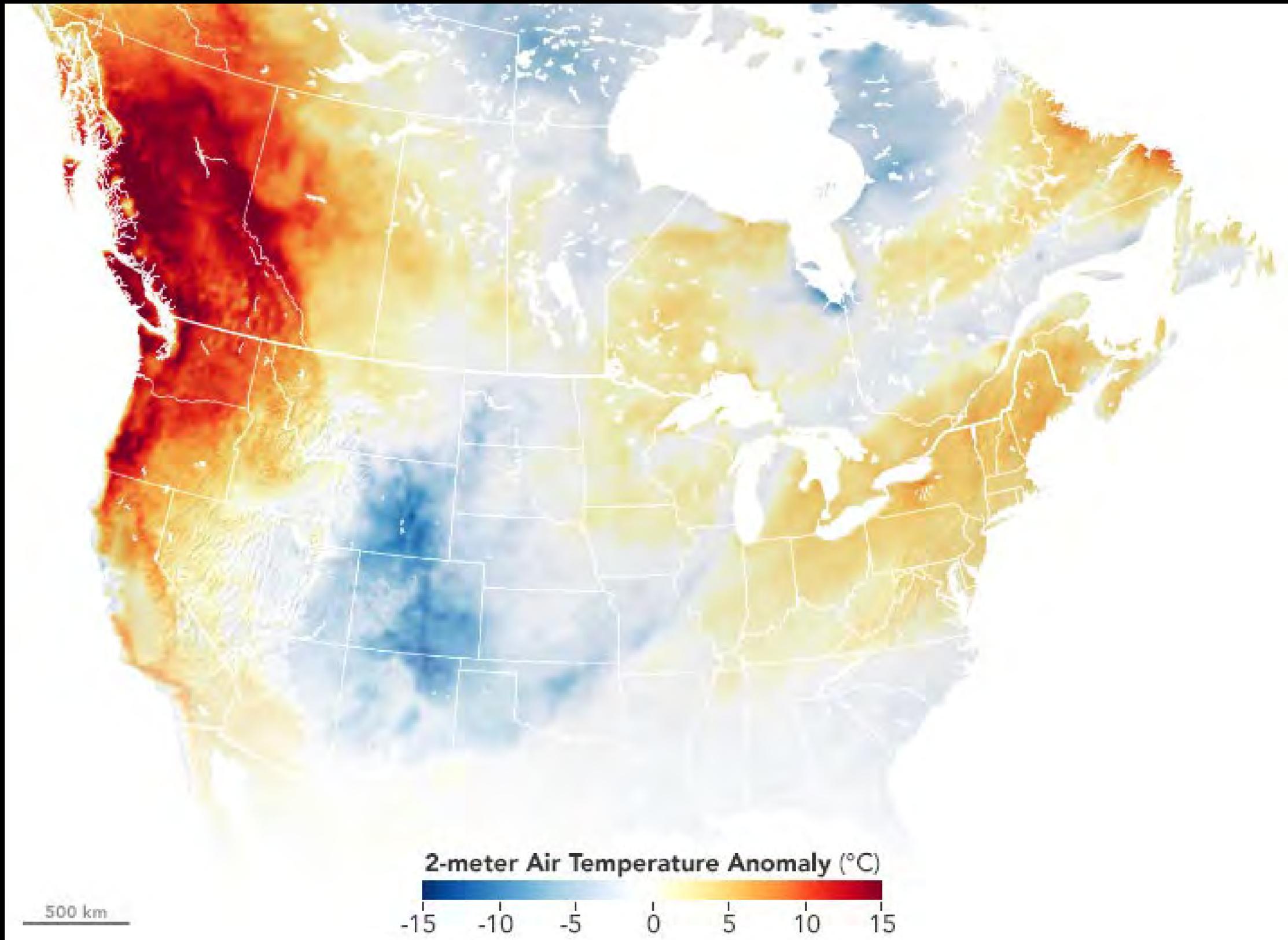
E/F1+ tornadoes. Top 20% of outbreaks. Outbreak defined as 6+ tornadoes in 6 hours nationwide
Source: Tippett et al. (2016)

CLIMATE CENTRAL

Recurrent acute disasters (RADs) are individual major hazard events that occur in a specific locale and create legacy conditions that impact future disasters in that locale.





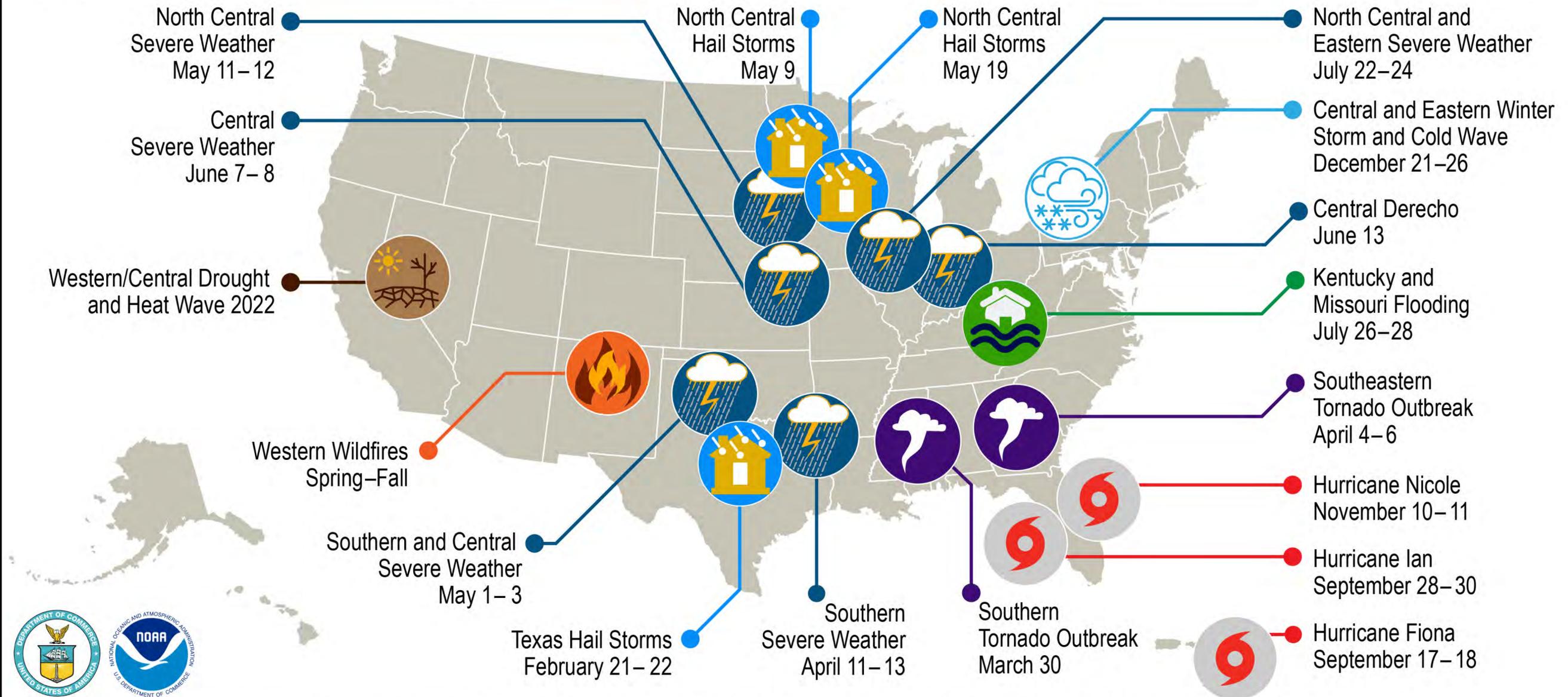




Current State of Affairs

U.S. 2022 Billion-Dollar Weather and Climate Disasters

-  Drought/Heat Wave
-  Flooding
-  Hail
-  Hurricane
-  Severe Weather
-  Tornado Outbreak
-  Wildfire
-  Winter Storm/Cold Wave



This map denotes the approximate location for each of the 18 separate billion-dollar weather and climate disasters that impacted the United States in 2022.

Applied Research Questions

- Is there a distinctive signature to recurring acute disasters and their impacts on human ecosystems?
- If so, what are the key legacy conditions that create these distinctive signatures, and can a theory be developed that could predict them?
- If so, what policies, programs, and actions can be undertaken to mitigate the harmful effects of recurring acute disasters, and support safety, protection of human life, and community resilience in the face of these recurring events?

A Case Study: Puerto Rico 2017-2022

- Hurricane Irma, 7 September 2017
- Hurricane Maria, 20 September 2017
- Island-wide drought, 11 February – 5 November 2019
- Earthquake series, 5-6 January 2020
- Hurricane Fiona, 18 September 2022

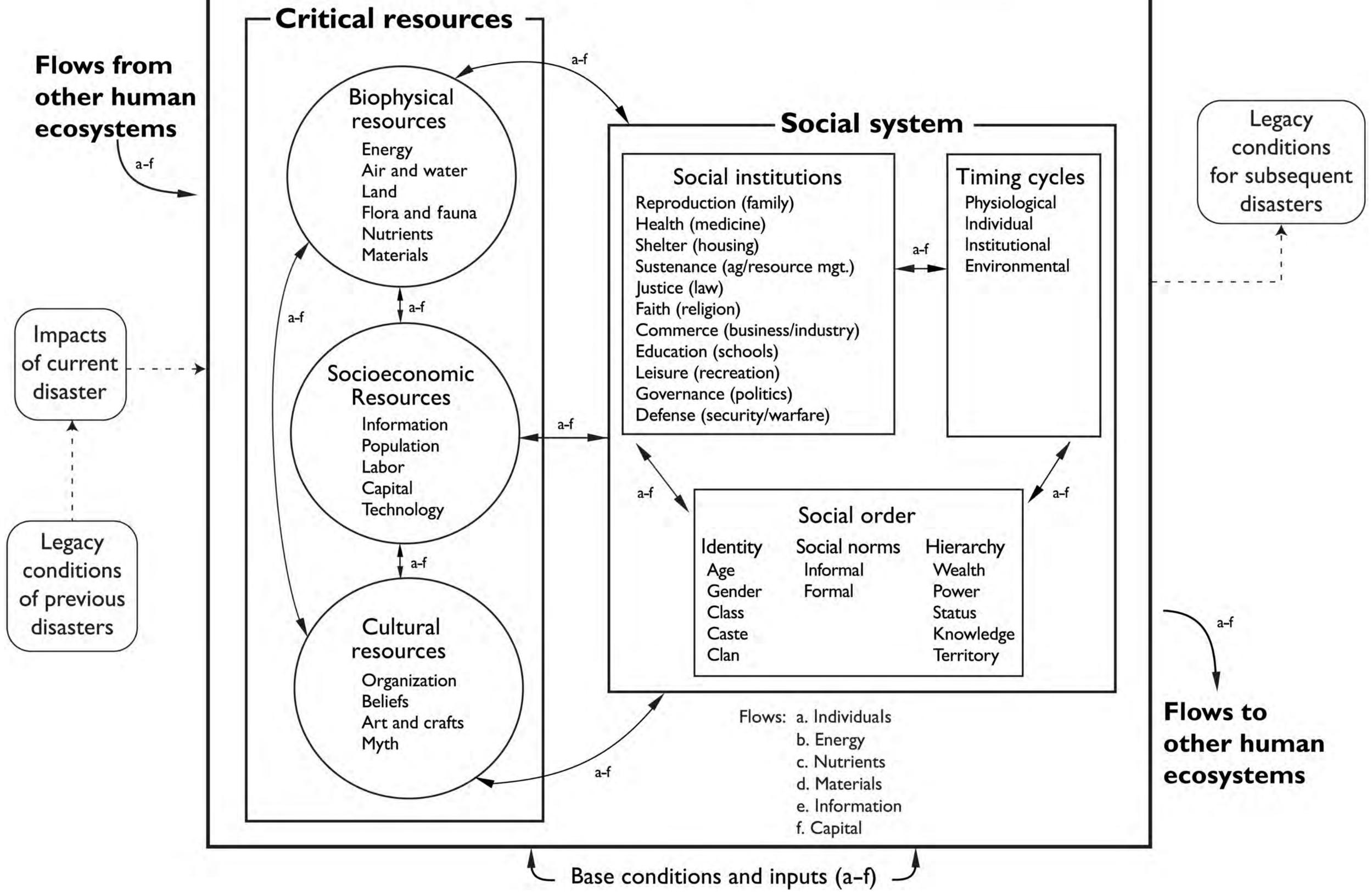


MODIS/VIIRS Products:

Primary: NASA's Black Marble,
MODIS NRT Floods

Secondary: MODIS BRDF/Albedo
LST, Land Cover, NDVI.

Human ecosystem



Human ecosystem

Critical resources

Biophysical resources
Energy
Air and water
Land
Flora and fauna
Nutrients
Materials

Socioeconomic Resources
Information
Population
Labor
Capital
Technology

Cultural resources
Organization
Beliefs
Art and crafts
Myth

Social system

Social institutions
Reproduction (family)
Health (medicine)
Shelter (housing)
Sustenance (ag/resource mgt.)
Justice (law)
Faith (religion)
Commerce (business/industry)
Education (schools)
Leisure (recreation)
Governance (politics)
Defense (security/warfare)

Timing cycles
Physiological
Individual
Institutional
Environmental

Social order
Identity: Age, Gender, Class, Caste, Clan
Social norms: Informal, Formal
Hierarchy: Wealth, Power, Status, Knowledge, Territory

Flows: a. Individuals
b. Energy
c. Nutrients
d. Materials
e. Information
f. Capital

Flows from other human ecosystems

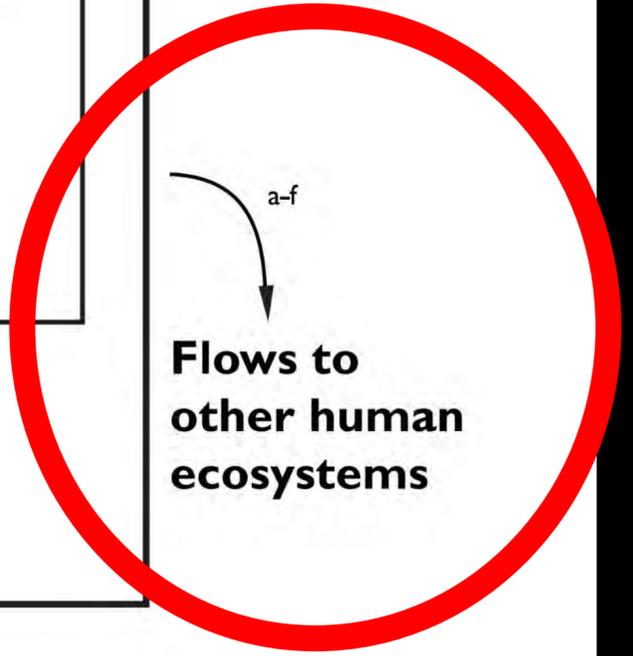
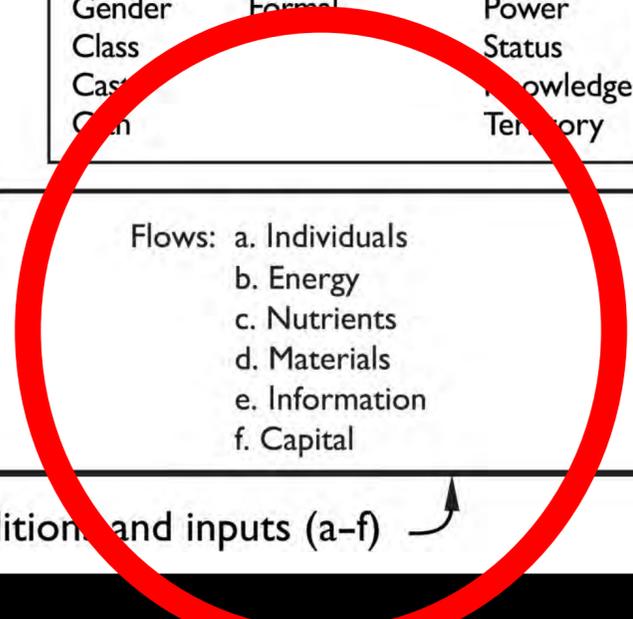
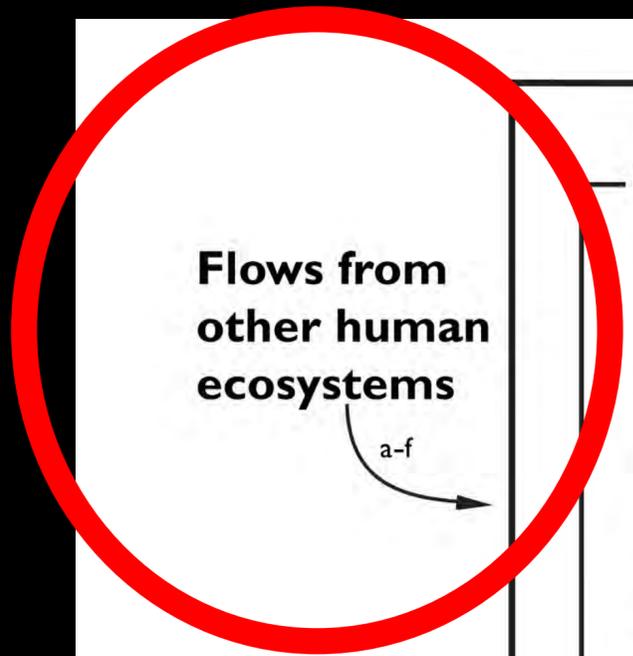
Impacts of current disaster

Legacy conditions of previous disasters

Legacy conditions for subsequent disasters

Flows to other human ecosystems

Base conditions and inputs (a-f)



abc NEWS

HURRICANE IRMA

SATELLITE

PUERTO RICO

ST. MARTIN

BARBUDA

ST. KITTS

GUADELUPE



Barbuda - Sept. 22, 2017

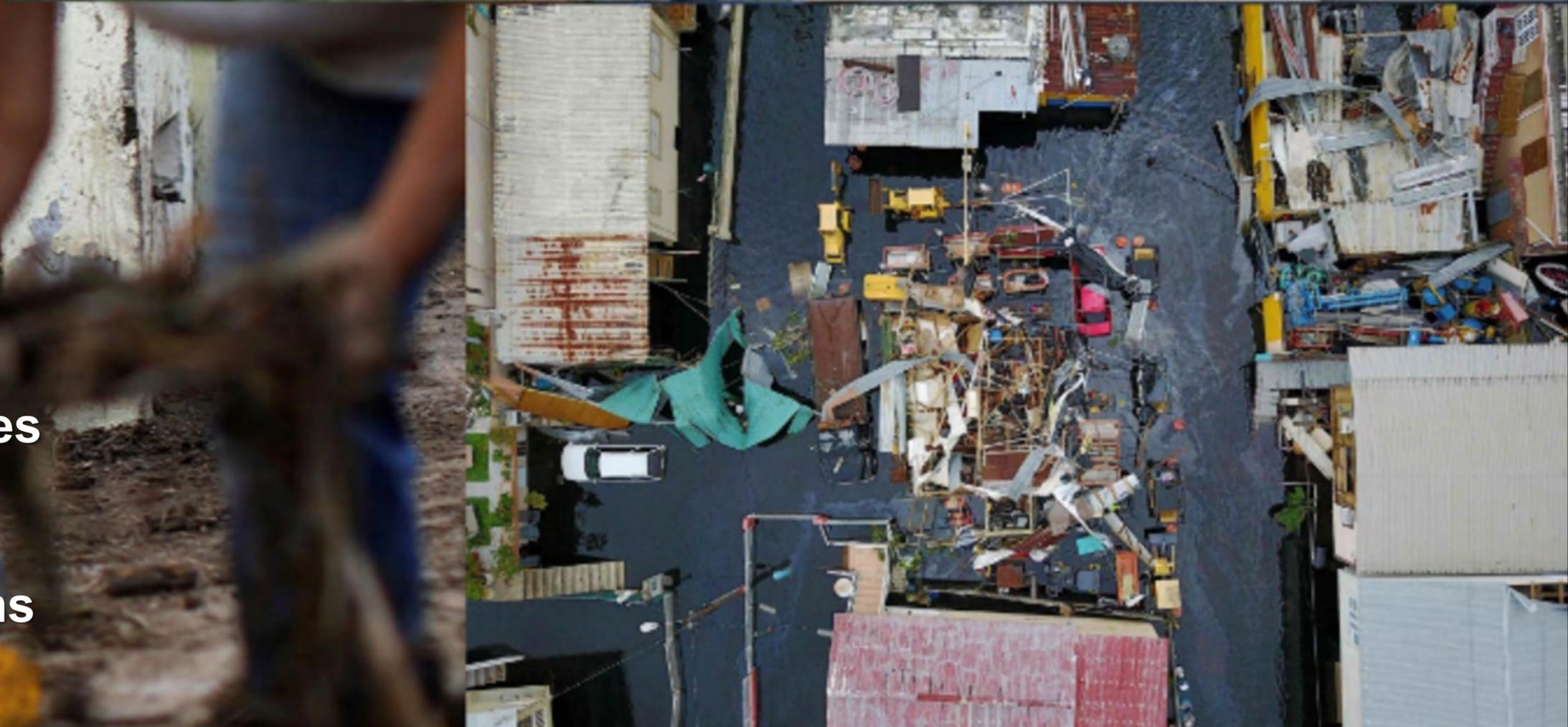






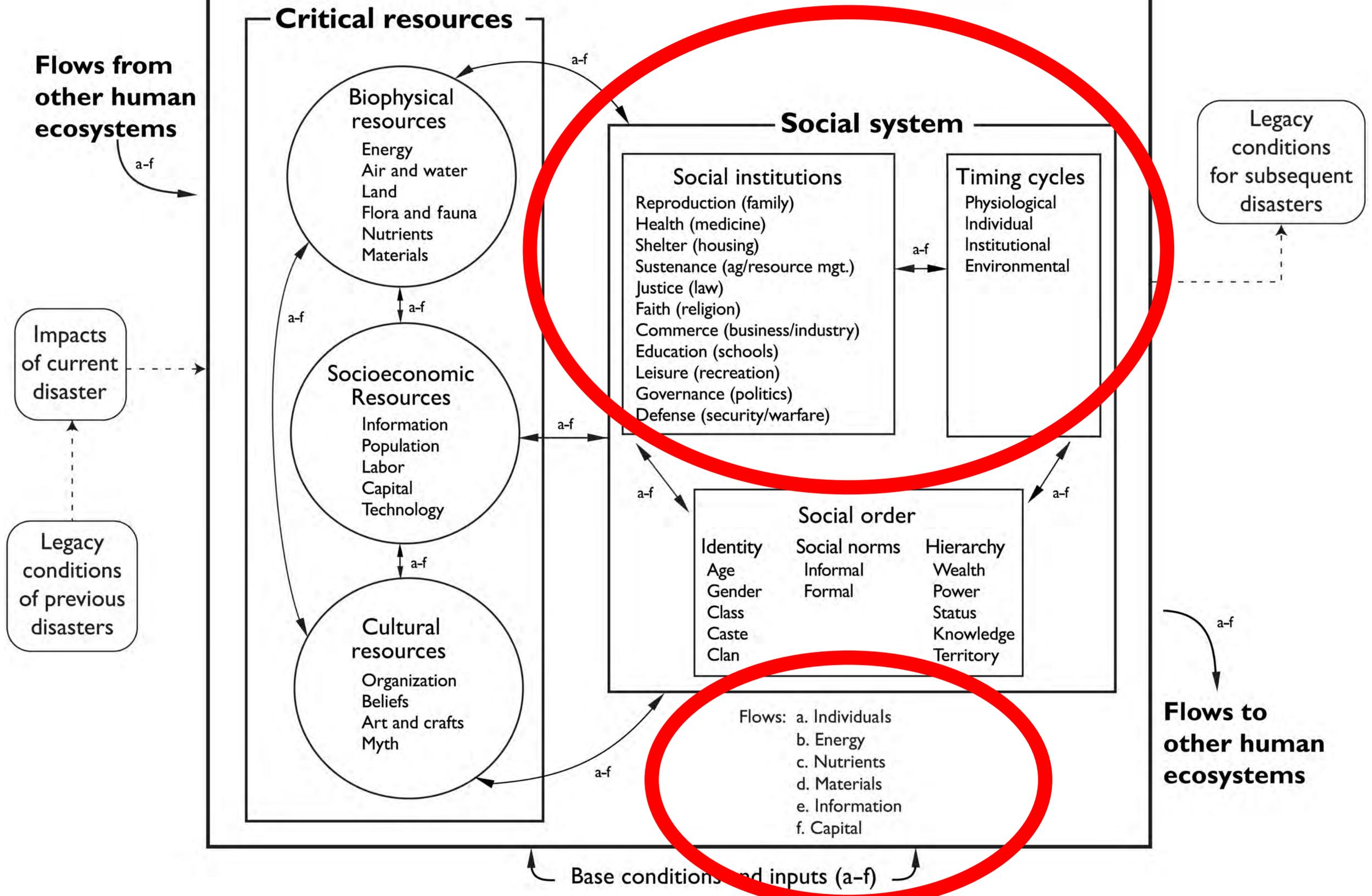
Image source: GOES 16 satellite image via NOAA
THE WASHINGTON POST

Legacy Conditions...



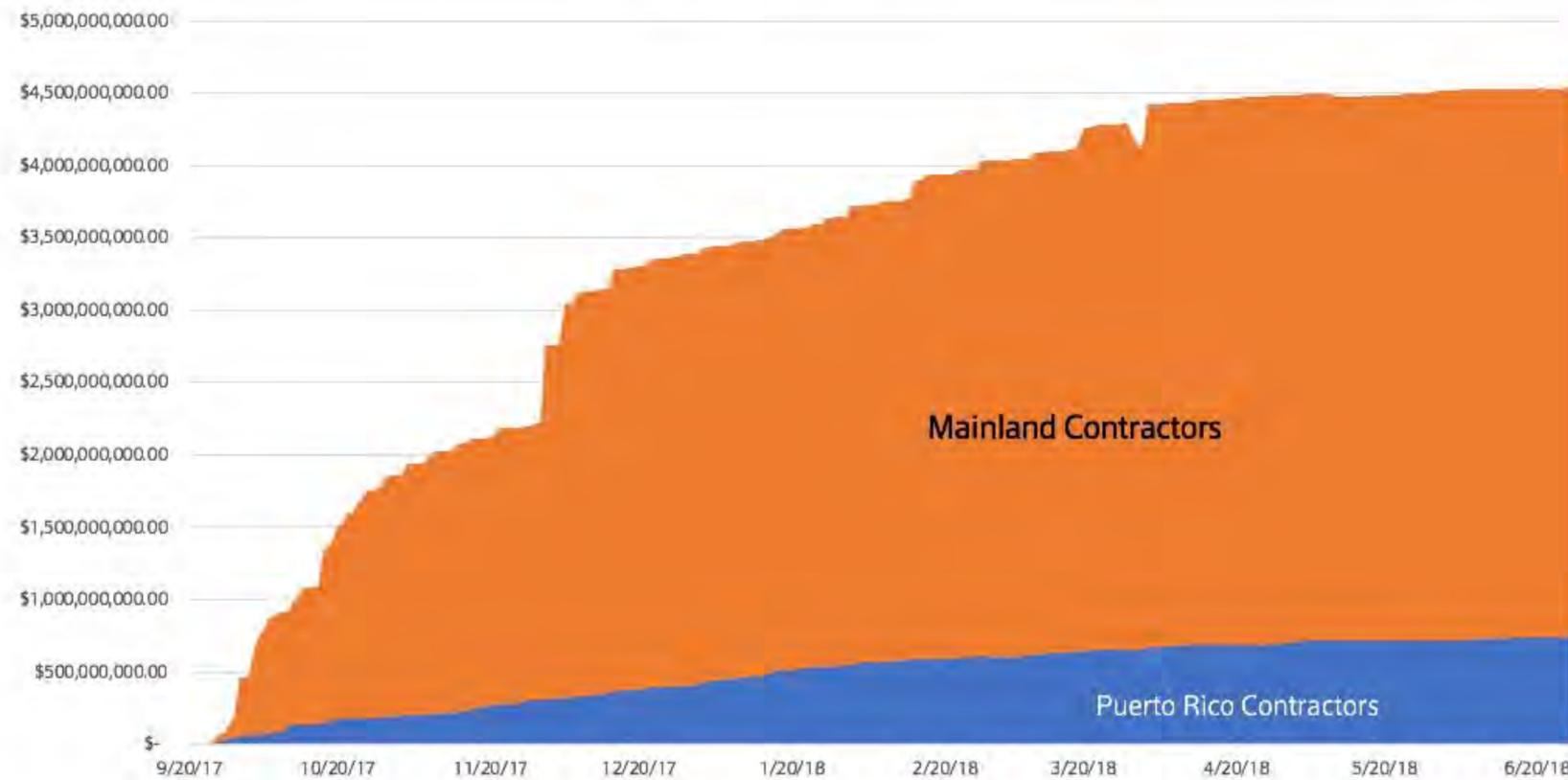
- \$ 90 billion dollars in damages
- -15% loss in GDP
- +4,645 lives lost
- Migration of +200,000 persons
- Emotional Impact: unknown

Human ecosystem

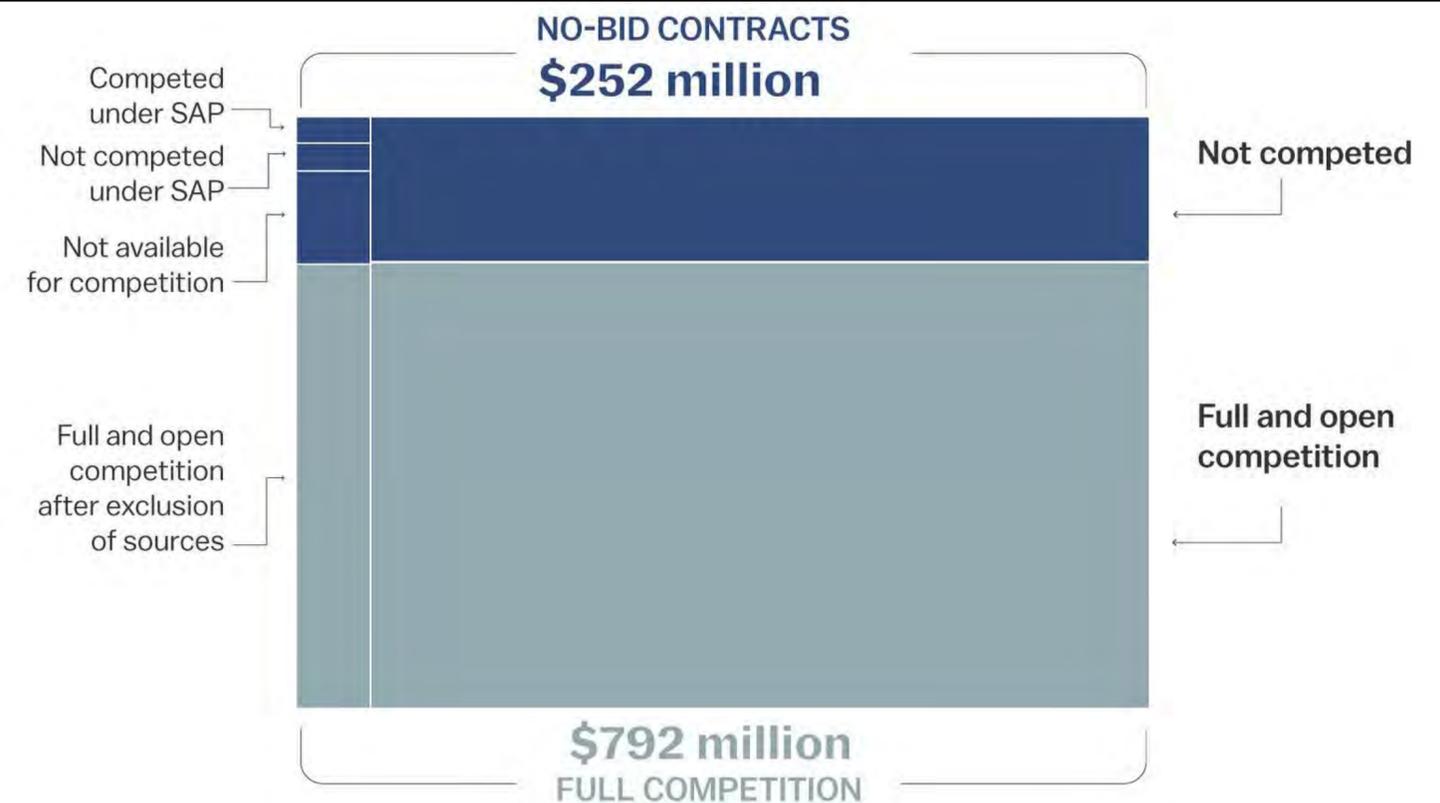


Follow The Money: Improving Public Accountability and Transparency

Accumulated Post Hurricane María Federal Expenditures in Puerto Rico by type of contractor



Source: CNE analysis of official US Government data



▲ Ninety percent of federal contracts have been granted to companies whose headquarters are outside of Puerto Rico (c. 2018).

▲ FEMA heavily relied on no-bid contracts in response to Hurricane Maria.



12 Shelf Stable meal Module

GLIF 333

Includes

12 Entree

12 Starch

12 Fruit

12 Dessert

12 Cavity Kit

Expiration June 9, 2018

Produced by LongBranch Partners, LLC, Ellen, GA 30540

690850



Advancing RAD Theory

The effects of a subsequent acute disaster on the human ecosystem at T_1 are a function of:

- 1) the condition of the human ecosystem at T_0 ;
- 2) the legacy conditions of previous disaster(s);
- 3) the geospatial union (0 to 1) of previous disaster(s);
- 4) the time gap between previous and subsequent disasters;
- 5) the response, recovery, and preparedness actions taken during the time gap; and
- 6) the type, intensity, and expansion rate of the subsequent disaster.

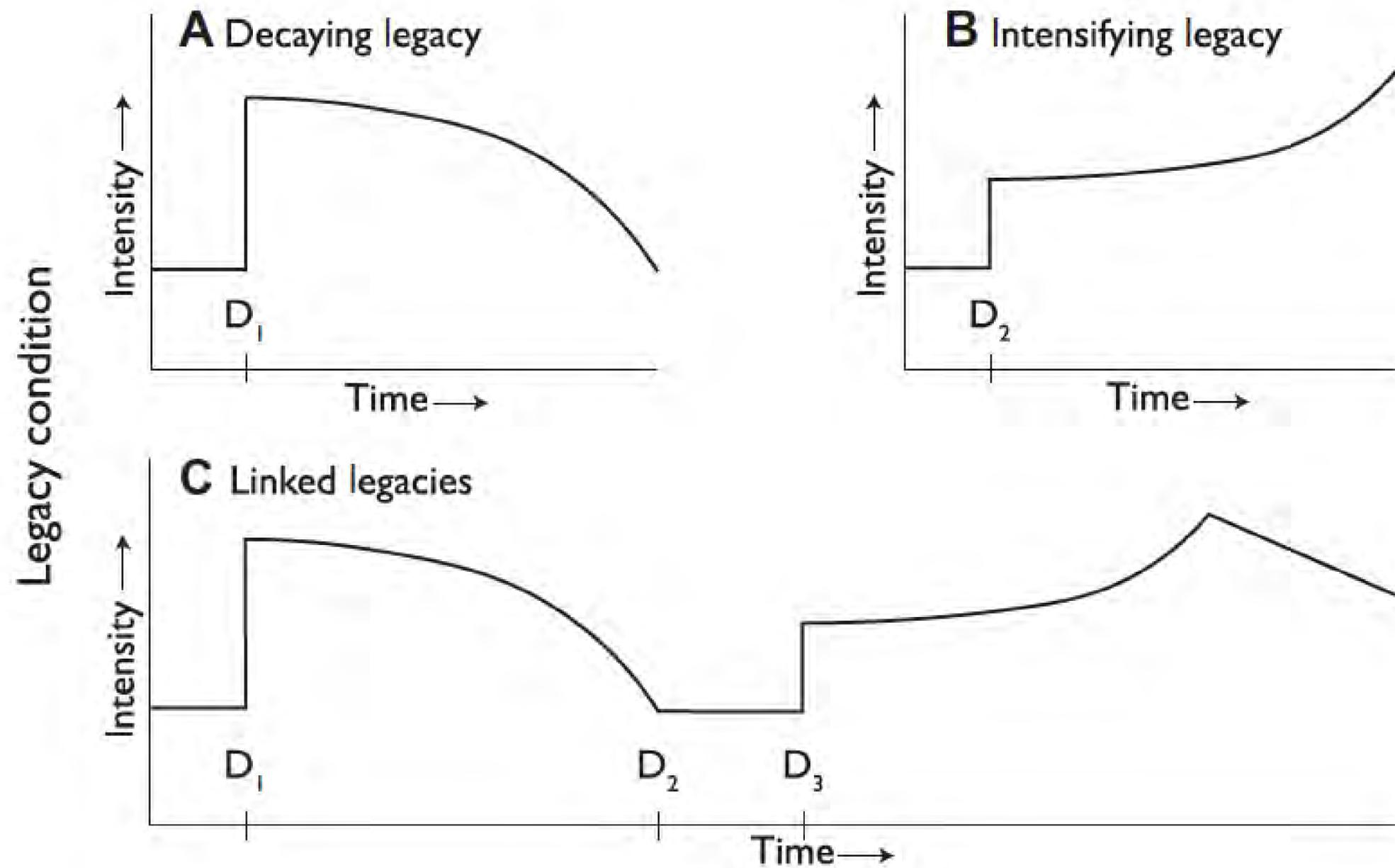


Fig. 3. A general schema of several categories of legacy conditions. (A to C) D_1 to D_3 represent RADs.

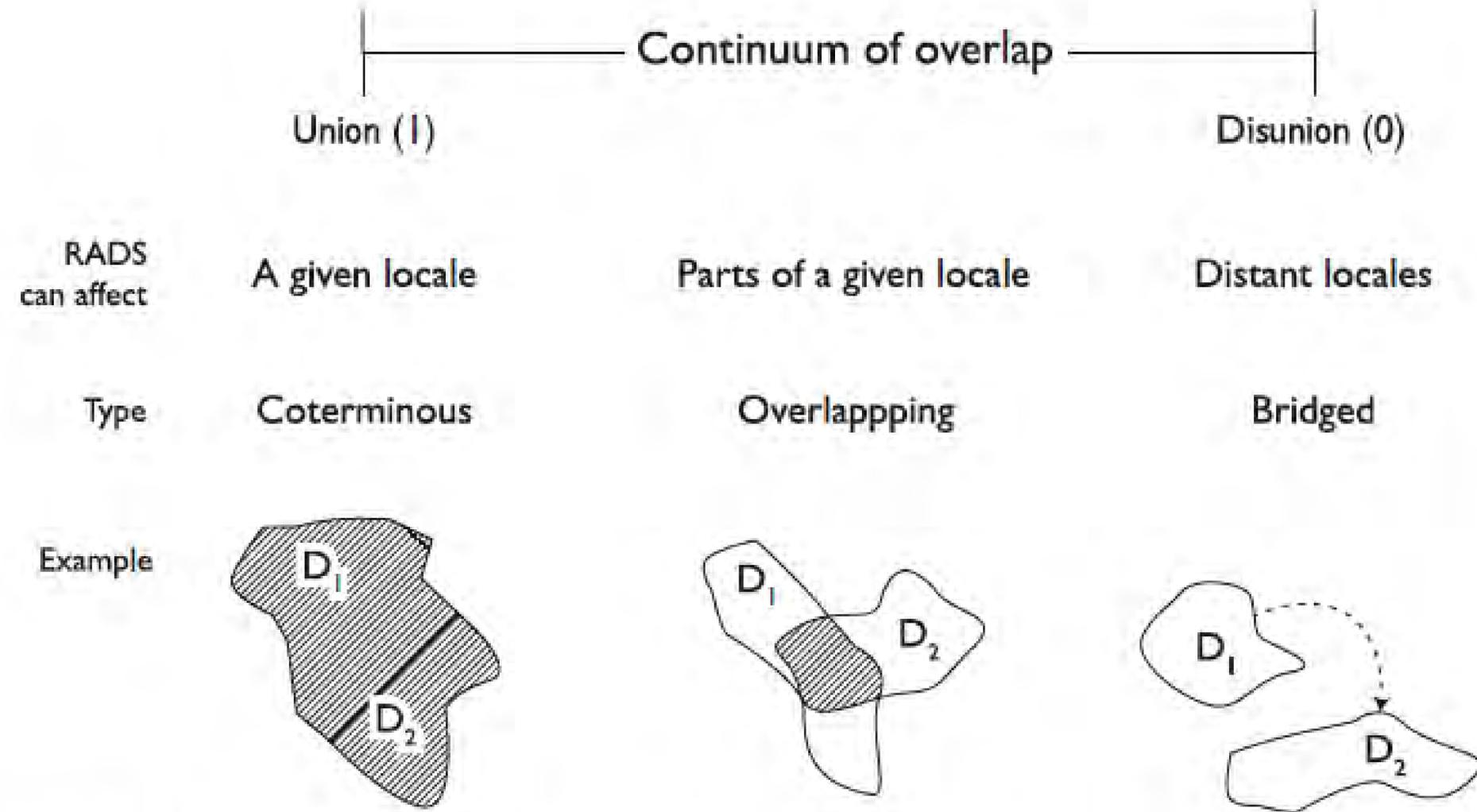


Fig. 1. A continuum of RAD spatial relationships. D_1 and D_2 represent RADs. Note that complete union (perfect spatial overlap of disasters) is improbable and disunion can vary by the spatial distance between bridged events.

National Aeronautics and
Space Administration



Earth at Night



EXPLORE
EARTH

<https://blackmarble.gsfc.nasa.gov/>

The Washington Post

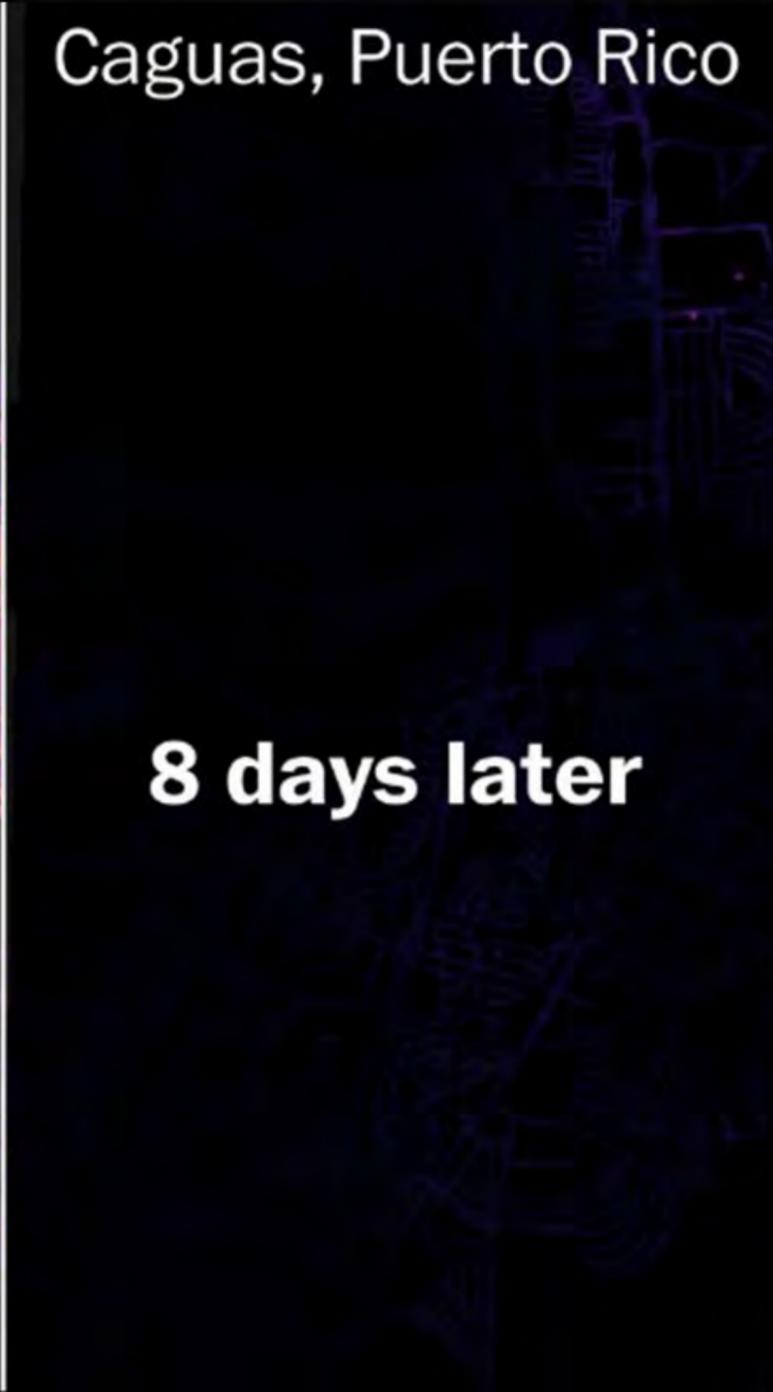
Democracy Dies in Darkness

Caguas, Puerto Rico

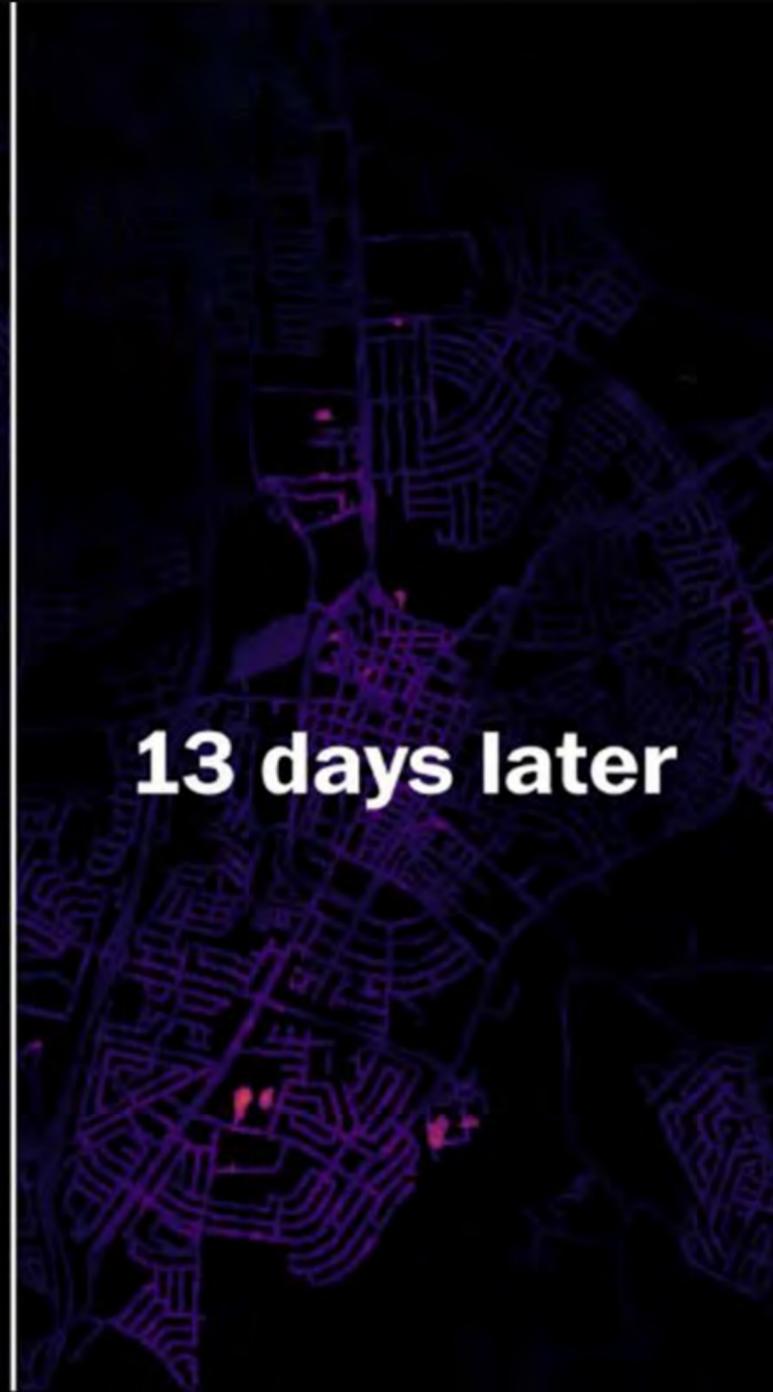
Before Maria

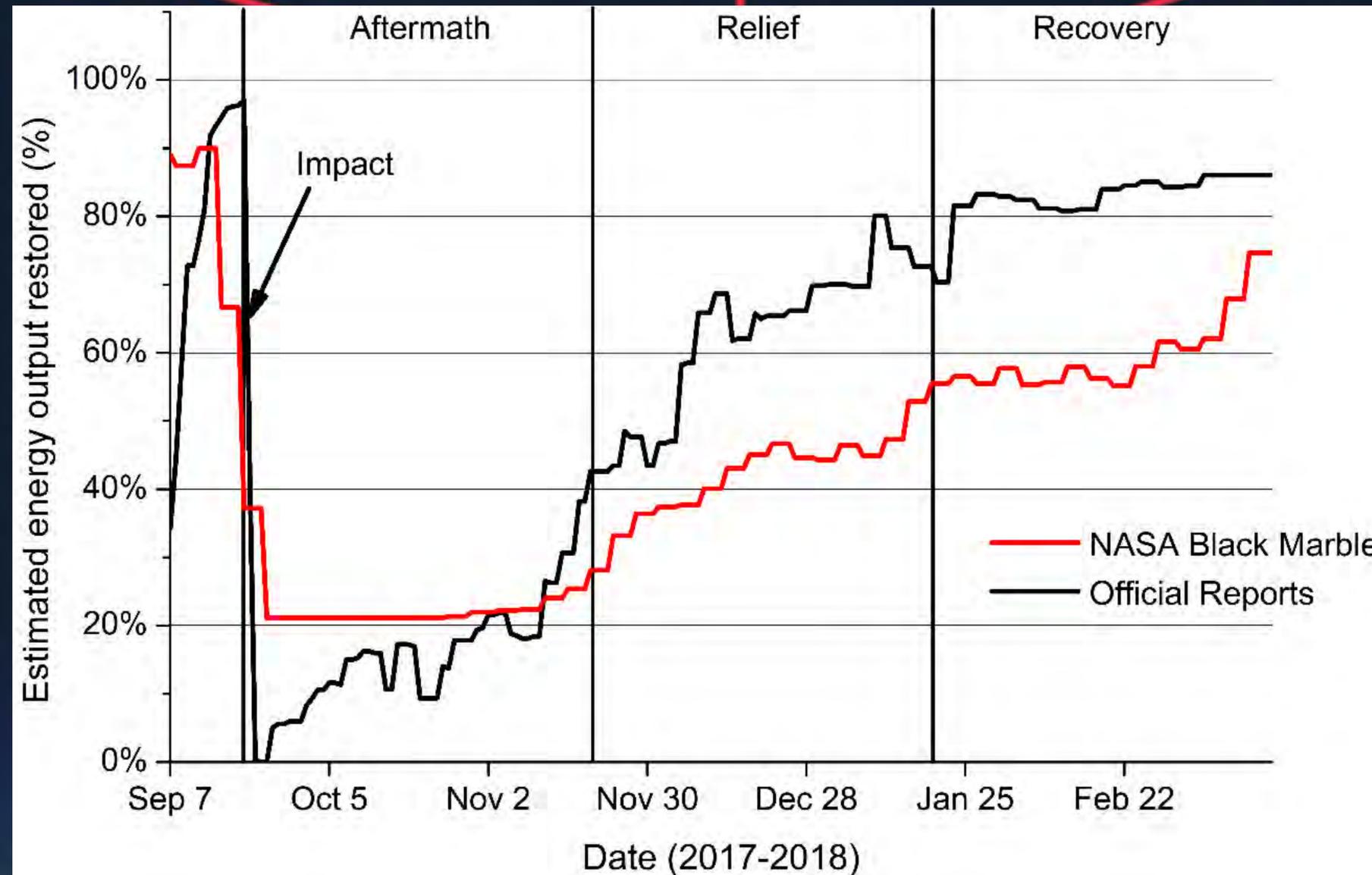


8 days later



13 days later

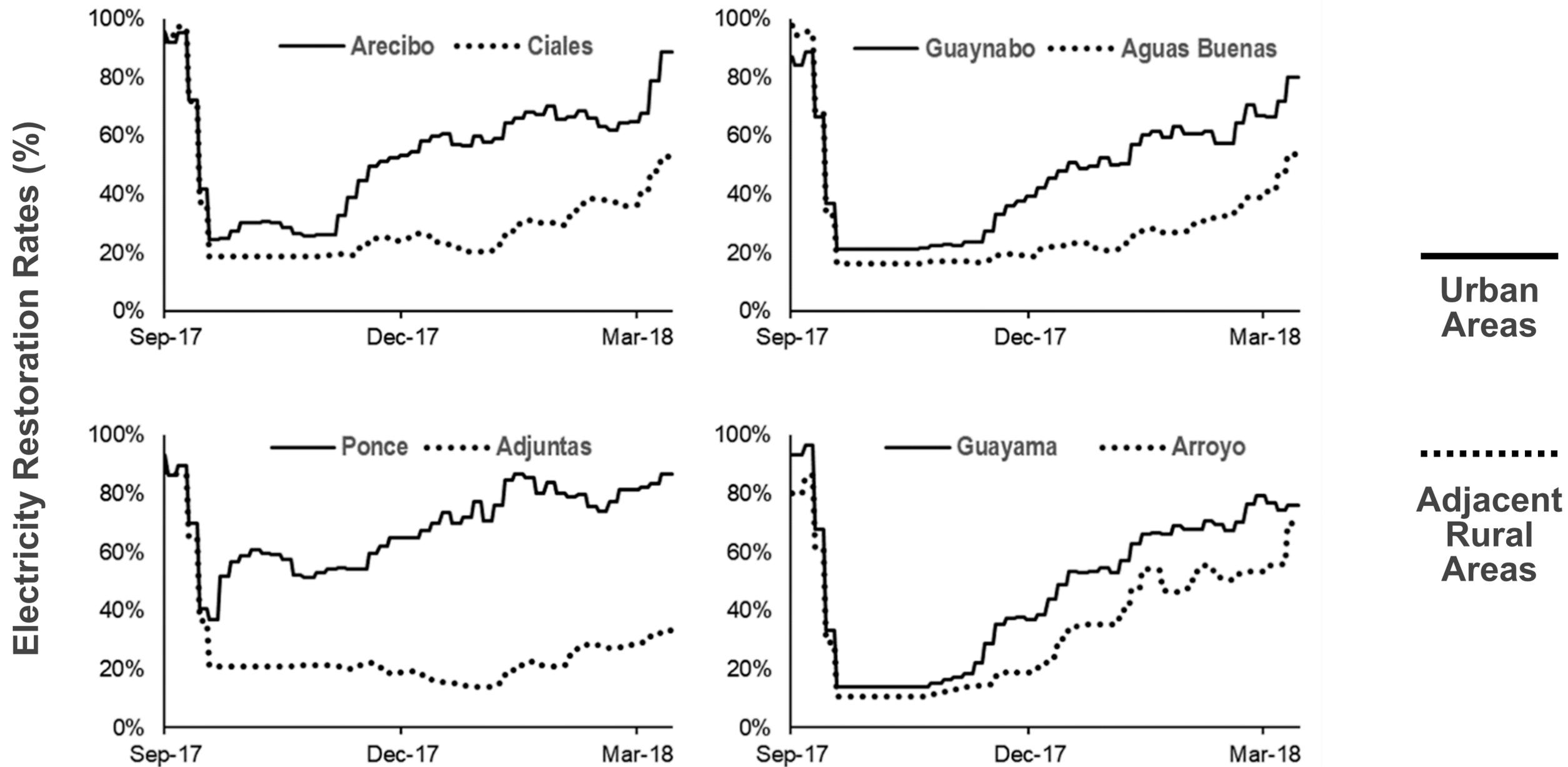




Román et al., (2019)
PLoS One

Proportion of Electricity Output Restored (%)

Inhabitants with Electricity (%) after Hurricanes Irma and Maria



Román et al., (2019)

Density-Vulnerability Tradeoffs...

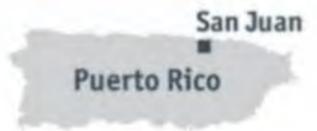




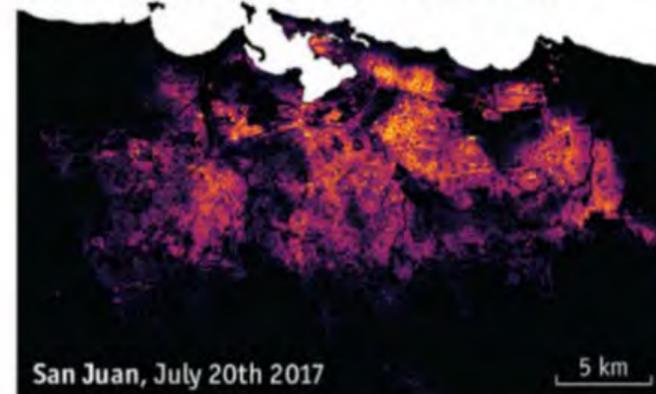
The Economist

Illuminating

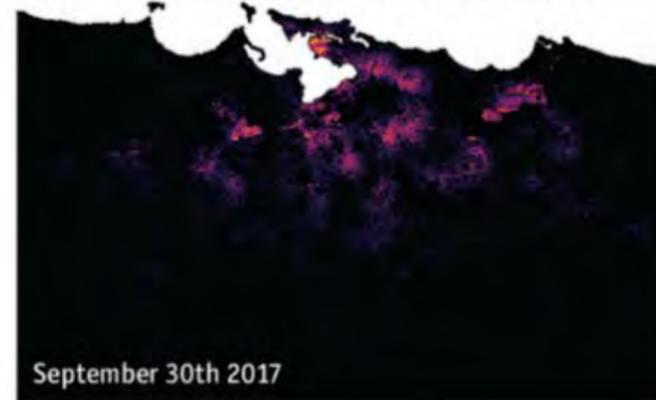
Night-light intensity in San Juan



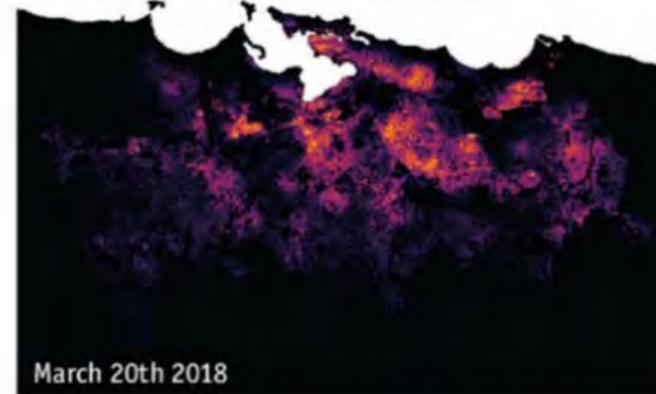
Before Hurricane Maria makes landfall



Immediate aftermath of Hurricane Maria



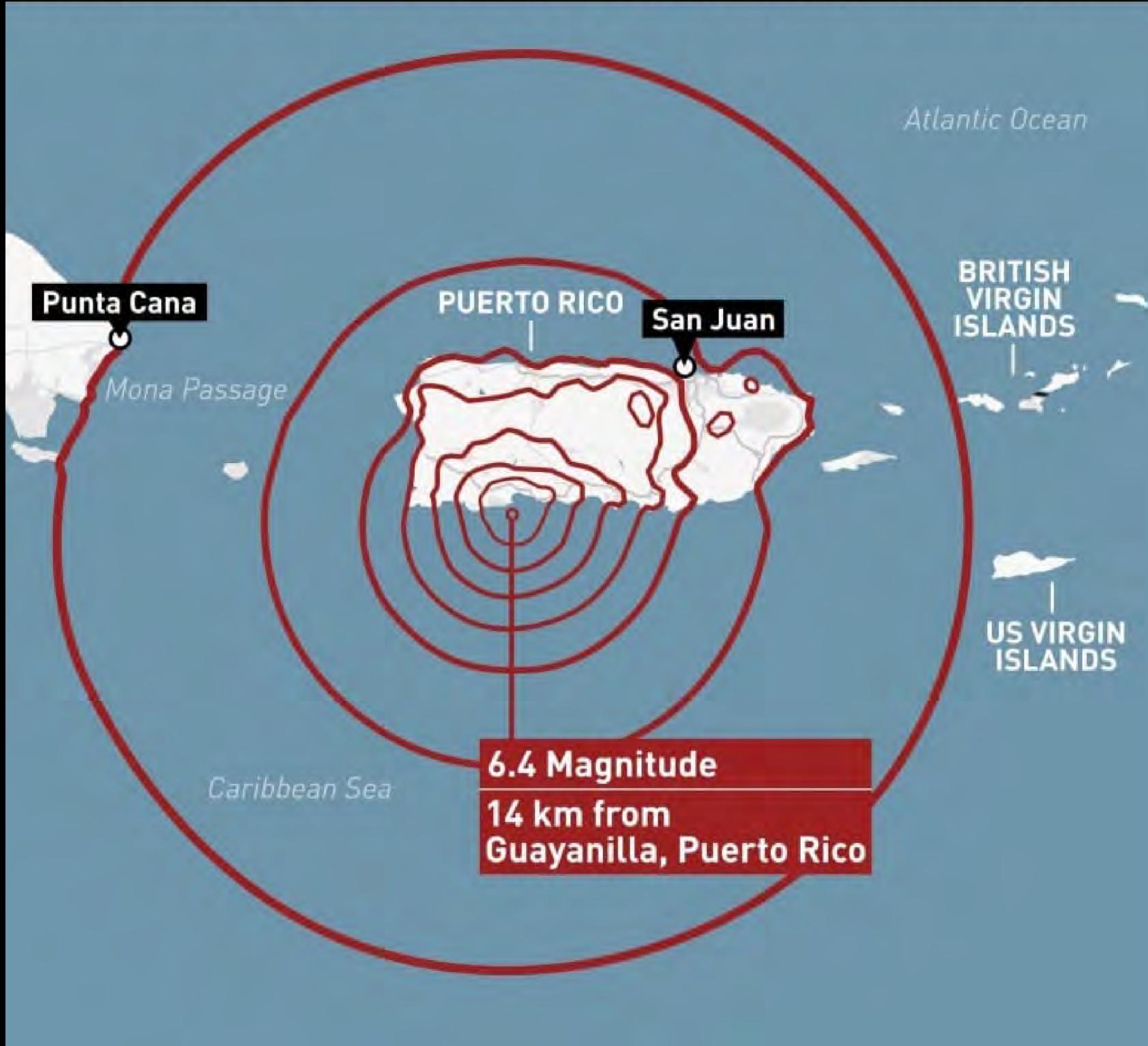
Six months after Hurricane Maria



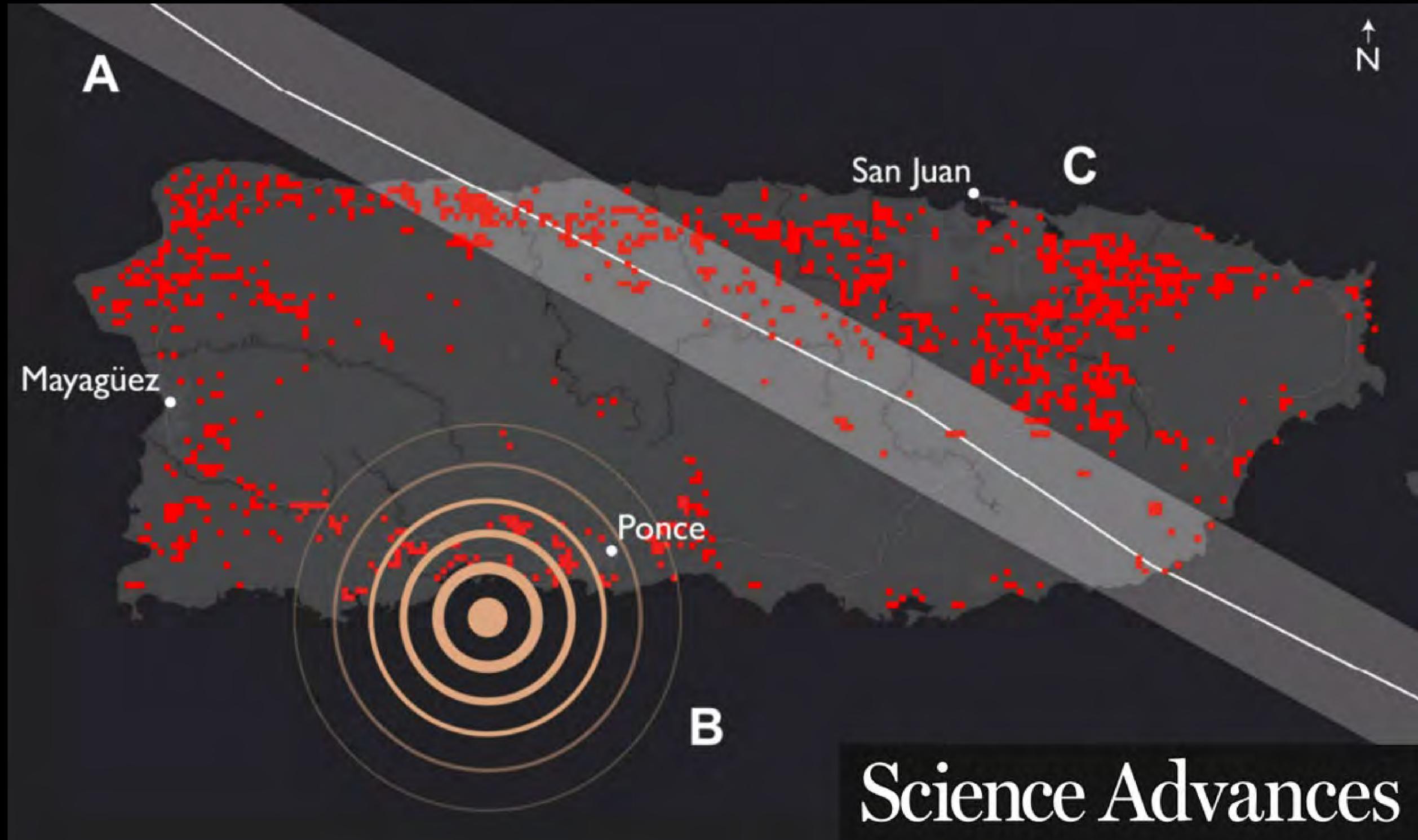
Source: Suomi NPP VIIRS data from Miguel Román, NASA Disasters Programme



6.4 earthquake off Puerto Rico's coast, January 7th



Map of the main island of Puerto Rico showing two bridged RADs.



[NATION](#)

Federal Emergency Management Agency

[Add Topic +](#)

Puerto Rico's Hurricane Fiona recovery efforts may be repeating same failures from Hurricane Maria, advocates say



[Christine Fernando](#)

USA TODAY

Published 5:48 a.m. ET Nov. 4, 2022 | Updated 2:25 p.m. ET Nov. 4, 2022



There are major discrepancies in the way Puerto Rico has prioritized the response to Hurricanes Maria and Fiona.

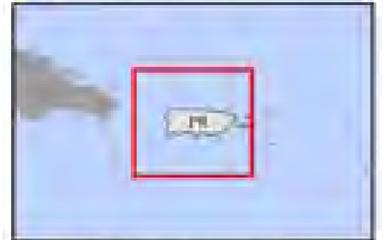
Bridge built in Puerto Rico after Hurricane Maria is swept away by Fiona floodwaters

Bridge PR-123, a temporary structure over the Guaonica River in Utuado, was destroyed the same day Hurricane Fiona made landfall on Puerto Rico.



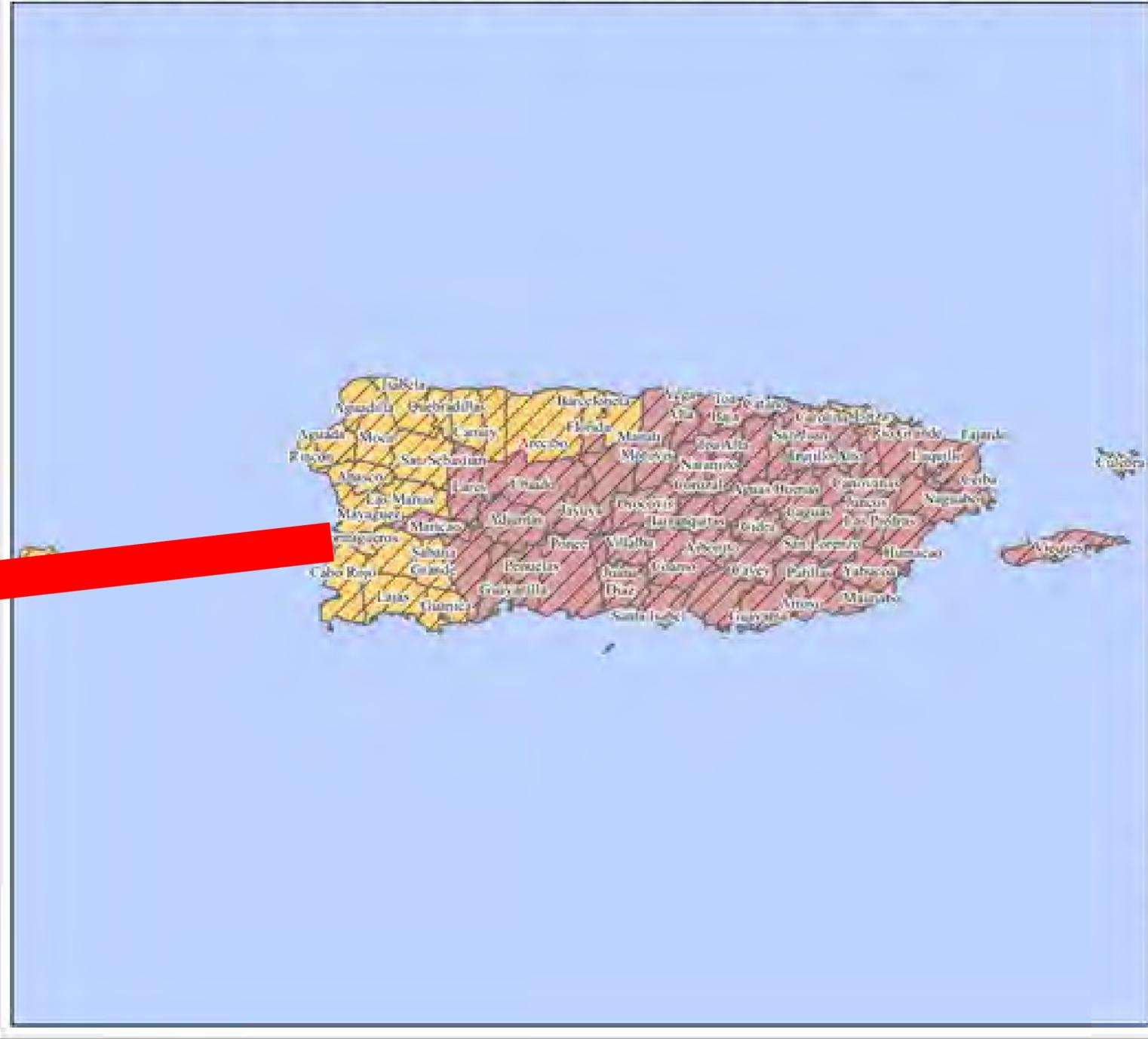


FEMA-4671-DR, Puerto Rico Disaster Declaration as of 09/21/2022



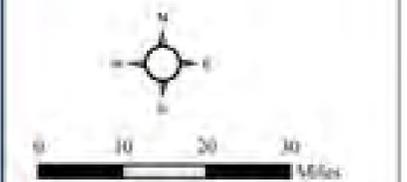
Data Layer/Map Description:
The types of assistance that have been designated for selected areas in the Commonwealth of Puerto Rico.

All municipalities in the Commonwealth of Puerto Rico are eligible to apply for assistance under the Hazard Mitigation Grant Program.



Designated Counties

- Public Assistance (Categories A and B)
- Individual Assistance and Public Assistance (Categories A and B)

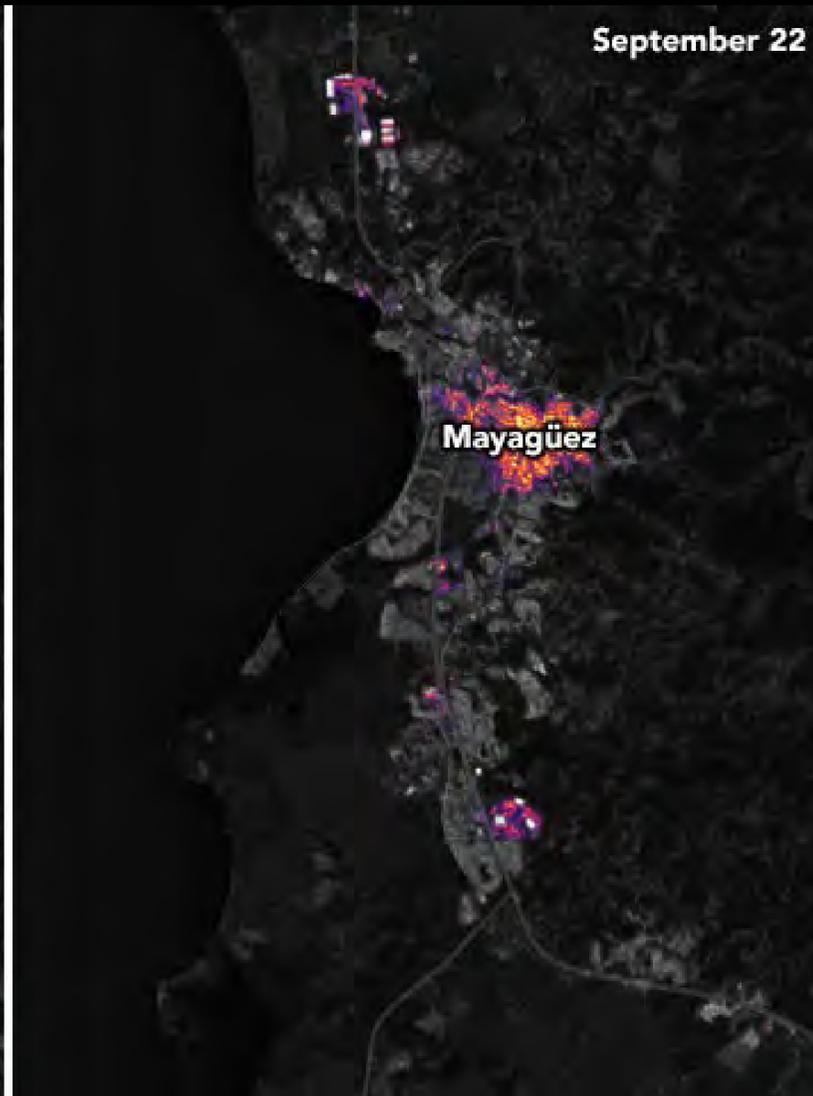


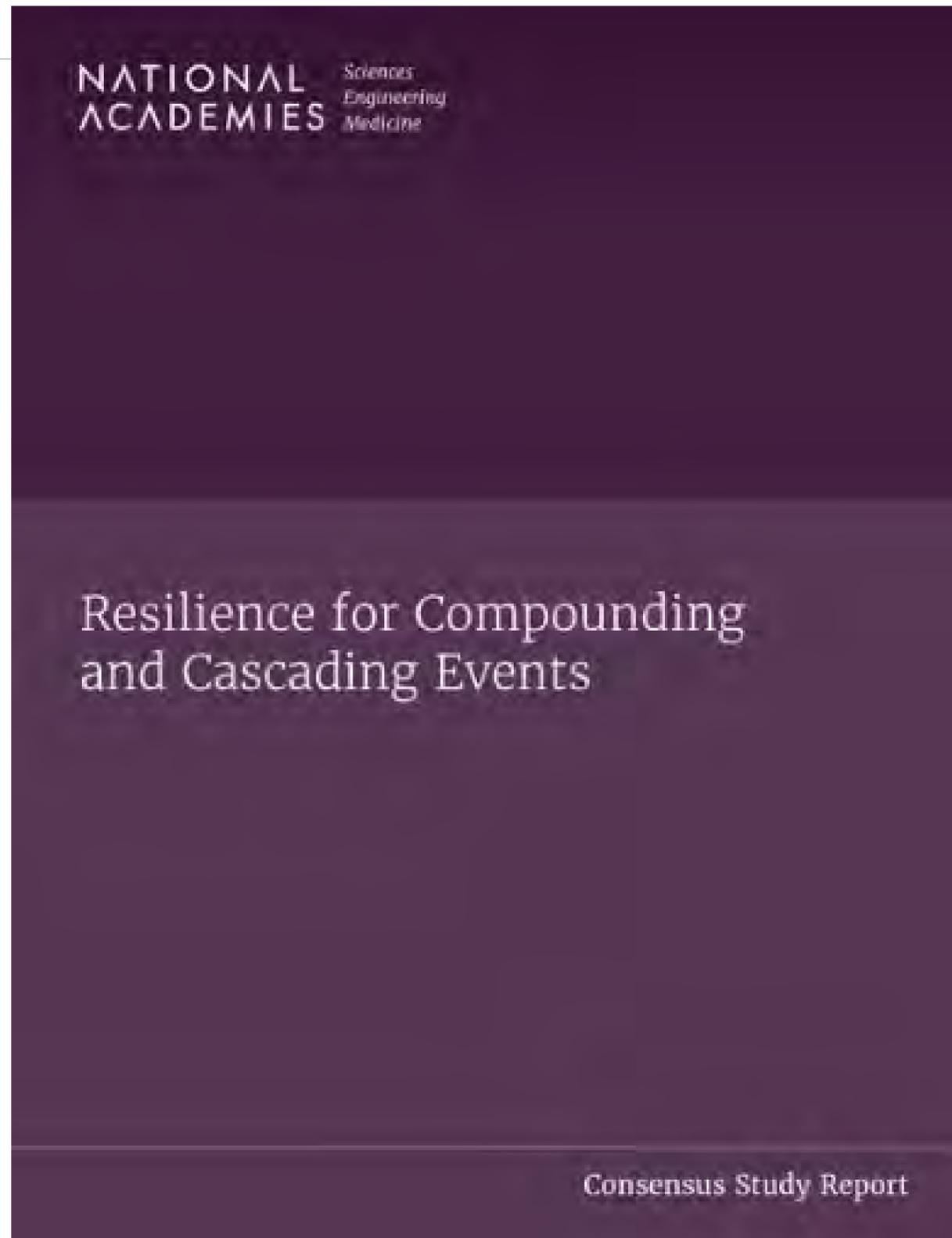
Data Sources:
FEMA, ESRI
Initial Declaration: 09/21/2022
Disaster Federal Registry Notice: 09/21/2022
Datum: North American 1983
Projection: Lambert Conformal Conic



OCTOBER 20, 2022

President Joseph R. Biden, Jr. Amends Puerto Rico Disaster Declaration





- Advance NASA’s foundational principles “*devoted to peaceful purposes of Space for the benefit of all humankind*” by prioritizing at-risk communities.
- Develop new frameworks that promote the sustainability of social-ecological systems under a changing climate.
- Understand legacy conditions within a Recurrent Acute Disasters (RAD) framework.
- Move beyond the “Billion \$ Disasters” mantra: Develop impact assessments that shine a light on underserved communities, households, and persons.